RELATING WATER QUALITY AND FISH OCCURRENCE: SPRING and SUMMER PATTERNS OF DISTRIBUTION FOR THREE SPECIES IN THE SAN FRANCISCO ESTUARY

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INTRODUCTION

Summer abundances of larval and juvenile striped bass, *Morone saxatilis*, longfin smelt, *Spirinchus thaleichthys*, and delta smelt, *Hypomesus transpacificus*, in the San Francisco Estuary have exhibited declines since the early 2000s (Fig 1). While there are credible hypotheses regarding the effect of habitat degradation on these fish species, there is some ambiguity surrounding the relationships between environmental quality in the Delta and fish presence. In an effort to examine these relationships, 12 years (1995-2006) of concurrent larval fish and water quality data were analyzed. Using a generalized additive model, striped bass, longfin smelt, and delta smelt presence/absence and distribution data were related to water temperature, electrical conductivity and secchi depth data.

The objectives of this analysis were to:

1) **analyze the relationships between fish occurrence and abiotic habitat variables, and**
2) **examine regional time trends in these variables.**

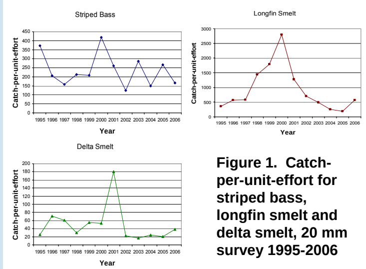

Figure 1. Catch-per-unit-effort for striped bass, longfin smelt and delta smelt, 20 mm survey 1995-2006

METHODS

Project Description:

California Department of Fish and Game's 20mm survey data were used for this analysis. This survey was implemented in 1995 to monitor larval and pre-juvenile delta smelt throughout their historical range. Each year, the study begins in early spring (Mar/Apr), and is conducted every other week through mid-summer (Jul/Aug). Over time, between 55 and 41 stations have been sampled; currently 41 stations are visited during each survey. To capture all possible presence data for each species, catch and water quality data from all stations and surveys sampled from 1995-2006 were used in this analysis.

Data Analysis:

Objective 1: A generalized additive model (GAM) was used to examine the relationships between fish occurrence and abiotic habitat variables. Temperature, electrical conductivity and secchi depth were inserted individually and in combination as predictor values of each species' occurrence. Statistical significance of the analyses was evaluated through use of chi-squared approximation. The GAM results provide predicted occurrence probabilities for each species in a given sample. These probabilities were used to describe habitat suitability, or environmental quality (EQ). To observe Delta-wide trends, the average EQ value for all stations in each year was plotted for each species.

Objective 2: A subset of all stations with at least 75 samples collected over the period of record was selected to examine regional trends. Seven regions, encompassing these 41 stations, were chosen (Fig 2). Linear regressions were run on all EQ values for each species in each region against year. The slopes of these regressions were used to indicate regional trends over time. GIS was employed to spatially depict these trends.

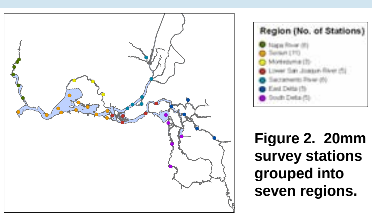

Figure 2. 20mm survey stations grouped into seven regions.

RESULTS

Temperature, electrical conductivity and secchi depth were all statistically significant predictors of species occurrence (P<0.05). Predicted occurrence of fish with respect to temperature varied among species. Striped bass predicted occurrence increased to approximately 22°C and plateaued with increased temperature; both longfin smelt and delta smelt showed similar patterns of increase to a maximum (15°C and 19°C, respectively) followed by declining occurrence with increased temperature (Fig 3). After an initial increase, predicted occurrence decreased with increased electrical conductivity for each species. Predicted occurrence decreased with increased values for secchi depth. The GAM that best explained the amount of deviance for all three species included both temperature and electrical conductivity, and was used in this analysis to describe EQ in the system.

In general, Delta-wide average EQ values for striped bass were highest, followed by longfin smelt and delta smelt (Fig 4). While EQ values for both striped bass and delta smelt had a small overall negative trend, EQ for longfin smelt showed a positive trend. However, all three species have shown a decline in the last quarter of sampling. Declines in EQ by region over time were detected for both striped bass and delta smelt as evidenced by the negative slopes obtained from linear regressions (Fig 5). Longfin smelt showed only positive slopes for all regions. Results obtained for the Napa River for striped bass and longfin smelt were not statistically significant (P>0.1). Statistically significant results were not obtained for delta smelt from either the Sacramento River or East Delta regions. All other results for all species were significant (P≤0.01).

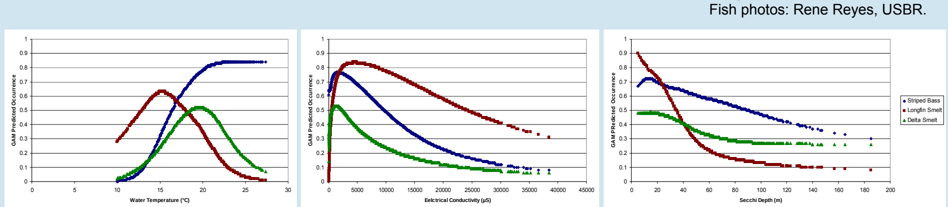

Figure 3. Predicted fish occurrence as obtained by generalized additive model for temperature, electrical conductivity and secchi depth.

DISCUSSION

This exploratory analysis was designed to examine relationships between species distribution and environmental quality. The results are limited to spring-summer larval fish distribution and water quality parameters. Therefore, the predicted fish occurrence values obtained describe seasonal conditions within the system. Initial results show a decline in EQ for both striped bass and delta smelt over the period of record (Fig 5). From 1995-2002, average late spring and early summer EQ has increased for longfin smelt; thereafter, annual upper estuary values have been decreasing.

The results of this analysis provide the groundwork for additional analyses that focus on the ability to predict fish occurrence based on the availability of suitable habitat. These results may be heavily influenced by seasonal conditions; therefore, future analyses should include both spatial and temporal variables in the GAM, allowing for these patterns to be detected. Because the relationship between declining EQ and species CPUE is not immediately evident within a given year, the model should also include presence/absence data based on species length and food presence. While the results of this analysis are not suitable for drawing connections between water quality and abundance within a year, overall averages for both CPUE and EQ have been declining for striped bass and delta smelt since 1995.

In addition to including these other predictor values of species occurrence in a GAM, selection of another statistical model may more accurately describe the relationships between habitat conditions and fish presence. A better understanding of the relationships between fish occurrence and abundance based on habitat suitability will give insight on population dynamics within the Delta and assist in management decisions.

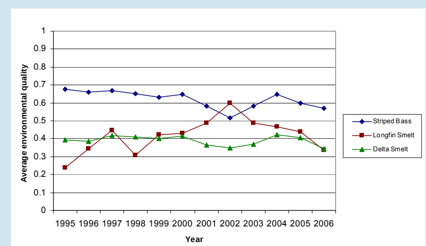

Figure 4. Average environmental quality for all stations by year.

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REFERENCE

Feyrer, F., M.L. Nobriga and T.R. Sommer. 2007. Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. Canadian Journal of Fisheries and Aquatic Sciences 64:723-734.

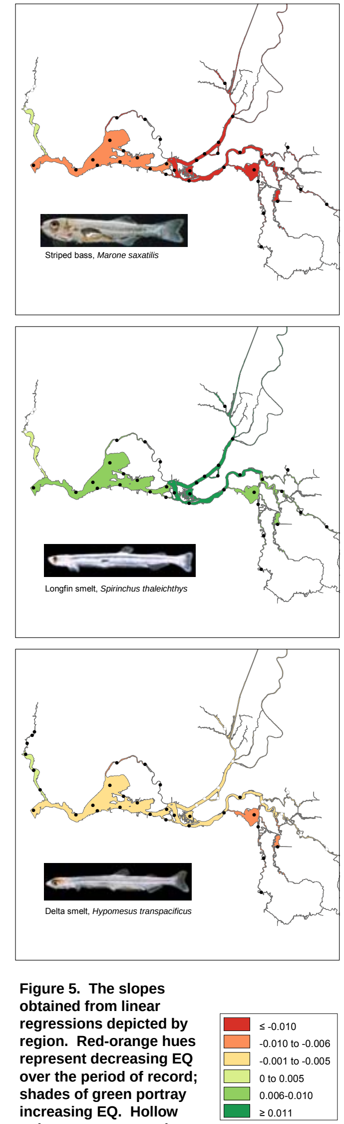

Figure 5. The slopes obtained from linear regressions depicted by region. Red-orange hues represent decreasing EQ over the period of record; shades of green portray increasing EQ. Hollow points represent stations with non-significant results.